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(19) THE PATENT OFFICE LONDON

(54) VEHICLE AXLE SPINDLE

(71) We, WILLOW HILL INDUSTRIES, INC., a corporation organized under the laws of the State of Ohio, United States of America, of 37611 Euclid Avenue, Willoughby, Ohio 44094, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of forming an axle spindle for use in supporting a vehicle wheel.

Many vehicles, such as cars and trailers, have axle spindles for supporting their wheels. These axle spindles are commonly formed of a solid piece of forged metal which is machined to accurately form bearing support surfaces. The cost of machining an axle spindle is increased when a passage must be bored through the solid spindle to receive either a speedometer cable and/or speed sensor cable of an anti-skid system. Of course, the relatively heavy weight of a solid axle spindle contributes to the unsprung weight of a vehicle.

It is an object of this invention to provide a method of forming an axle spindle which is hollow to minimize the weight of the spindle and to provide an axially extending passage to facilitate the installation in a vehicle of equipment requiring the extension through the spindle of a cable or other conductor.

According to the present invention there is provided a method of forming a hollow axle spindle for use in supporting a vehicle wheel which, in use, is rotatably mounted on the spindle by a plurality of bearing assemblies located in axially spaced apart relationship between an outer end portion of the spindle and an inner end portion of the spindle connected with the vehicle, said method comprising the steps of: providing a metal blank of approximately the same length as the axle spindle and having an axially extending tubular wall having open ends and a substantially uniform external diameter with an annular cross-sectional configuration in a radially extending plane; providing a support stake having substantially the same external configuration as the internal configuration of the hollow axle spindle and having a first portion, a second portion and an intermediate portion between the first and second portions, the intermediate portion being of smaller cross-sectional area than said first portion, and the second portion being of smaller cross-sectional area than said intermediate portion; positioning the blank on the stake with one end portion of the blank adjacent to the first portion of the stake; providing a plurality of dies; cold forging at least a portion of the metal blank adjacent to the first and intermediate portions of the stake at a temperature below the recrystallization temperature of the metal of the blank by effecting relative axial movement between at least one of the dies and the blank and stake to form adjacent to the first portion of the stake a mounting end portion of the spindle for connection with a vehicle and to form adjacent to the intermediate portion of the stake a first cylindrical bearing support section having substantially cylindrical inner and outer surfaces which extend substantially parallel to each other in a co-axial relationship with the longitudinal axis of the blank and are uniformly spaced from each other by a first distance; cold forging at least a portion of the metal blank with at least a second one of the plurality of dies at a location which is axially outwardly of the first bearing support section and at a temperature which is below the recrystallization temperature of the metal of the blank to form adjacent to the second portion of the stake a second cylin-

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drical bearing support section having a smaller external diameter than the first cylindrical bearing support section and having substantially cylindrical inner and outer surfaces which extend substantially parallel to each other in a coaxial relationship with the first bearing support section and are uniformly spaced from each other by a second distance which is greater than the first distance between the inner and outer surfaces of the first cylindrical bearing support section thereby to form a second cylindrical bearing support section with a greater metal thickness in a radial direction than the first bearing support section, and removing the cold forged blank from the stake after performing the foregoing steps.

In order that the invention may be well understood, some embodiments thereof, given by way of example only, will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration of a portion of the front suspension system of a vehicle;

Figure 2 is an enlarged fragmentary view of a portion of the vehicle suspension system of Figure 1 and illustrating the relationship between a wheel hub, wheel bearing assemblies, and a hollow axle spindle constructed in accordance with the present invention;

Figure 3 is a sectional view, on a somewhat reduced scale of a tubular blank from which the hollow axle spindle of Figure 2 is formed by a cold working process;

Figure 4 is a schematic sectional view illustrating the tubular blank of Figure 3 after it has been cold worked to form a grease seal section on the blank;

Fig. 5 is a schematic sectional view illustrating the blank of Fig. 4 after it has been cold worked to form an inner bearing support section;

Fig. 6 is a schematic sectional view of the tubular blank of Fig. 5 after it has been cold worked to form an outer bearing support section and outer end portion;

Fig. 7 is a schematic view illustrating the blank of Fig. 6 after an inner end portion of the blank has been expanded to form a base section;

Fig. 8 is a schematic sectional view of the blank of Fig. 7 after the base section has been cold worked to form a mounting section;

Fig. 9 is a sectional view, taken generally along the line 9-9 of Fig. 8, further illustrating the construction of the outer bearing support section;

Fig. 10 is a sectional view, taken along the line 10-10 of Fig. 8, further illustrating the construction of the inner bearing support section;

Fig. 11 is a sectional view, taken along the line 11-11 of Fig. 8, further illustrating the construction of the grease seal section; and

Fig. 12 is a fragmentary sectional view of a hollow axle spindle which is formed separately from an associated axle tube.

The general arrangement of a front suspension system 20 (shown in Fig 1) is, per se, known and includes an axle 24 which is connected with a steering knuckle 26 by upper and lower control arms 28 and 30. A coil spring 34 is provided between the lower control arm 30 and the axle 24. A wheel 36 is rotatably mounted on a hollow axle spindle 22 in a known manner by an inner or main wheel bearing assembly 40 (Fig. 2) and an outrigger or outer wheel bearing assembly 42.

The spindle 22 is shown in Fig. 2 in association with a speedometer cable 48 which extends through a central cavity 52 in the hollow spindle into operative engagement with a grease cap 54 which rotates with the hub 44 of the wheel 36. The speedometer cable 48 drives a speedometer (not shown) of the vehicle in a known manner at a speed which is directly proportional to the speed of rotation of the grease cap 54 and wheel 36. Of course, the axially extending cavity 52 provides a convenient passage for conductors other than the speedometer cable 48. For example, when the axle spindle 22 is associated with either a rear or front wheel of a vehicle, conductors for a speed sensor of an anti-skid system can be extended through the hollow spindle and operatively connected with the wheel to enable the associated anti-skid apparatus to detect an impending locking up or skidding of the wheel.

The hollow axle spindle 22 includes an inner bearing support section 58 upon which the main or inner bearing assembly 40 is mounted and an outer bearing support section 60 upon which the axially outer bearing assembly 42 is mounted. The inner and outer bearing support sections 58 and 60 are coaxial and have cylindrical outer surfaces 64 and 66 which have an interference fit with cylindrical inner surfaces on inner races 68 and 70 (Fig. 2) of the bearing assemblies 40 and 42. Under normal operating conditions, the inner bearing support section 58 is subjected to greater operating stresses than is the base section 72 of the spindle 22. Therefore, the inner bearing support section 58 advantageously has a greater wall thickness than does the base section 72.

The inner bearing assembly 40 is positioned axially relative to the spindle 22 by engagement of an inner end portion of the bearing assembly with a generally radially projecting surface 74 of a bearing positioning shoulder 76. The inner bearing support

section 58 has a larger external diameter than does the outer bearing support section 60 and is connected with the outer bearing support section by a radially inwardly and axially outwardly tapering connecting section 80. A bearing nut 84 engages a threaded outer end portion 86 of the spindle 22 and presses a washer 88 against the bearing assembly 42 to retain the bearing assembly 42 against axially outward movement relative to the spindle 22. Thus, the inner and outer bearing assemblies 40 and 42 are positioned relative to the spindle 22 by engagement of the inner bearing assembly 40 with the positioning shoulder 76 and by engagement of the outer bearing assembly 42 with the wheel hub 44 and the washer 88 and nut 84. It should be understood that the positioning shoulder 76 may be omitted and the inner bearing assembly positioned axially relative to the spindle 22 by engagement with the steering knuckle 26.

A known grease seal 92 extends between the hub 44 and a grease seal section 96 of the spindle 22. The grease seal 92 seals the annular opening between the spindle 22 and the interior of the hub 44 to prevent grease from leaving a grease chamber 98 between the hub 44 and spindle 22 and to keep dust from entering the grease chamber. Since the inner bearing support section 58 is normally subjected to greater operating stresses than the grease seal section 96, the inner bearing support section advantageously has a greater wall thickness than does the grease seal section.

The base section 72 has an interference fit with a cylindrical cavity 102 in the steering knuckle 26. An annular weld 104 circumscribes the circular base section 72 to securely interconnect the spindle 22 and steering knuckle 26. Of course, the spindle 22 could be fixedly connected to the steering knuckle 26 in a manner other than the specific manner illustrated in Fig. 2.

Since the axle spindle 22 is hollow, the weight of the spindle is substantially less than the weight of a similar solid axle spindle which has heretofore been commonly utilized on automobiles and other vehicles. The relatively low weight of the hollow axle spindle 22 tends to minimize the unsprung weight of a vehicle with which the axle spindle is associated. In one specific embodiment of the invention a hollow axle spindle, similar to the axle spindle 22, weighed approximately one half as much as did a solid axle spindle of a similar size and configuration. In addition, the provision of the cavity 52 in the hollow spindle 22 enables a speedometer cable 48 or other conductor to be operatively connected with the wheel 36 without incurring the expense of boring or drilling an axially extending passage through the spindle. It should be noted that when the hollow spindle 22 is utilized in association with a vehicle wherein a speedometer cable or similar conductor is not to be extended through the hollow spindle, the outer end of the cavity 52 could be blocked if desired.

The hollow axle spindle 22 is economically made by cold working or forming a tubular blank 110 (see Fig. 3) with a plurality of dies 114-122 in the manner illustrated schematically in Figs. 4 through 8. Prior to beginning cold forming operations, the hollow blank 110 is positioned on an upstanding stake or support member in a known metal working press. The upstanding stake (not shown) has an external configuration which is substantially similar to the surface of the cavity 52 in the hollow spindle 22. The press is then operated in a known manner to sequentially move a plurality of dies relative to the blank 110. Representative dies 114-122 are shown schematically in Figs. 4-8.

As each of the dies 114-118 engages the blank 110 in turn, the metal of the blank is forced through an opening in the die to plastically deform the metal at a temperature below its recrystallization temperature. While the blank 110 is being cold worked in this manner, the cylindrical outer surfaces 64 and 66 of the bearing support sections are precisely formed within the relatively small tolerance range and surface finish required to provide an interference fit with the inner races 68 and 70 (Fig. 2) of the bearing assemblies 40 and 42. Therefore, the surfaces 64 and 66 do not have to be precisely formed by machining operations as has heretofore been a common commercial practice. In addition, the cold working of the metal of the blank 110 results in a strain hardening and impartation of directional properties to the metal with a resulting increase in the structural strength of the spindle 22.

The tubular blank 110 (Fig. 3) has an annular wall 128 of uniform thickness and which is defined by cylindrical inner and outer surfaces 130 and 132 which are disposed in a coaxial relationship with each other. The tubular wall 128 has a length which is somewhat shorter than the length of the spindle 22 since the cold working of the blank 110 results in some axial growth of the blank. The tubular wall 128 has an external diameter of the base 72 of the spindle 22 since the tubular wall 128 is expanded somewhat (see Fig. 7) to form the base 72. However, it should be understood that the blank 110 could be cold worked in such a manner as to form the base 72 without expanding the tubular wall 218.

The die 114 (Fig. 4) defines a central passage or opening 138 which has a circular cross-section configuration and an axially extending surface configuration corresponding to the shape of the cold worked blank 110a shown in Fig. 4. The cylindrical blank 110 of Fig. 3 is cold worked to form the blank 110a by first moving the die 114 into axial alignment with the blank 110 and then moving the die axially downwardly along the blank. This movement results in the tubular wall 128 of the blank 110 being plastically deformed radially inwardly at a temperature below the recrystallization temperature of the metal to form the blank 110a. It should be noted that the grease seal section 96 is partially formed by this movement of the die 114.

The die 114 is then raised clear of the blank 110a and the blank is indexed to a position in which it is in axial alignment with the die 116. The die 116 is then axially lowered to cold work the blank 110a and thereby form the blank 110b of Fig. 5. It should be noted that this movement of the die 116 initiates the formation of the inner bearing support section 58 and the tapering connector section 80 which are coaxial with the grease seal section 96. Considerable strain hardening will have occurred by this time in the blank 110b. Therefore, the blank 110b is advantageously annealed before continuing with the cold forming operation.

The annealed blank 110b is then moved into axial alignment with the die 118 which is telescoped axially with the blank 110b to form the blank 110c shown in Fig. 6. The upper portion of the blank 110c has a configuration corresponding to the configuration of the spindle 22. Thus, the die 118 forms the final configuration for the bearing positioning shoulder 76 and the coaxial bearing support sections 58 and 60. In addition, the die 118 forms the outer end portion 86 on which threads are subsequently rolled to enable the bearing nut 84 to be threaded onto the spindle 22.

Once the upper or outer portion of the blank 110c has been formed, the bottom or inner portion of the blank 110c is cold worked to form the base section 72 which is coaxial with the other sections of the spindle 22. Thus, the blank 110c is moved into axial alignment with the expanding die 120 which is pressed into the lower end portion of the blank 110c. This expands the tubular wall of the blank 110c radially outwardly to form the blank 110d (Fig. 7). A mounting section 144 is then formed on the base 72 by compressing the base inwardly in a manner shown schematically in Fig. 8 with the die 122. The mounting section 144 is received in the cavity 102 of the steering knuckle 26 (Fig. 2) and advantageously includes a shoulder 148 for positioning the spindle 22 relative to the steering knuckle.

The cold working of the blank 110 to form the spindle 22 is completed once the mounting section 144 has been formed on the base 72 by the die 122. However, threads must still be rolled, in a known manner, on the outer end portion 86 of the spindle. It should be understood that the base 72 could, if desired, be formed by reducing the diameter of a blank having a relatively large diameter rather than by expanding the blank. However, by reducing the diameter of the blank 110 to form the bearing support sections 58 and 60 and expanding the blank 110 to form the base section 72, the extent of movement of the metal of the blank in a radially inward direction and in a radially outward direction tends to be minimized.

By varying the shape of the openings 138 in the dies 114 through 118, the shape of the spindle 22 can be varied. Thus, the opening 138 could be shaped in such a manner as to provide the cylindrical bearing support sections 58 and 60 with either an inwardly projecting slot or an outwardly projecting protruberance to assist in retaining the inner races 68 and 70 of the bearing assemblies 40 and 42 against movement relative to the spindle 22. Of course, the specific illustrated configuration of the spindle 22 could be varied to suit the particular requirements of a vehicle with which the spindle 22 is to be associated. In addition, the relative axial movement between the blank and the dies in the cold working process could, if desired, be performed by moving the blank 110 rather than the dies 114-122.

It should be understood that the sequence of cold working steps shown in Figs. 4 through 8 are merely representative of the steps which are performed during the cold working operation. The specific number of dies and steps required to form the spindle 22 from a hollow blank 110 will vary depending upon the metal from which the blank is made and the physical size and configuration of the spindle 22. For example, a blank 110 formed of SAE 1010 steel tubing would have to be shaped by a relatively large number of dies having metal forming surfaces which differed by a lesser extent relative to each other than do the surfaces 138 of the dies 114-122.

During the cold forming operation illustrated schematically in Figs. 4 through 8. the metal of the tubular wall 128 of the blank 110 (Fig. 3) is plastically deformed either radially inwardly or outwardly at a temperature below the recrystallization temperature of the metal to form the various sections of the spindle 22. While

a small portion of this metal is displaced axially and results in an axial growth of of blank 110, most of the metal of the tubular wall 128 is moved in a radial direction. Therefore, the metal area measured on a radial plane extending through the wall 128 of the blank 110 (Fig. 3) is substantially equal to the metal area measured on a radial plane through the various sections of the spindle 22.

Since the wall of the spindle 22 has an annular cross sectional configuration with a constant metal area at the various sections of the spindle, the radial thickness of the annular wall of the spindle decreases as the external diameter of the wall increases. This is perhaps best seen by a comparison of the cross sectional configurations of the inner and outer bearing support sections 58 and 60. The outer bearing support section 60 has a relatively small diameter and a relatively large wall thickness, designated 152 in Fig. 9. The inner bearing support section 58 has a larger external diameter than does the outer bearing support section 60 and has a smaller wall thickness, indicated at 154 in Fig. 10. The thickness 152 of the outer bearing support section 60 is sufficiently greater than the thickness 154 of the inner bearing support section 58 so that the metal area between a cylindrical inner surface 158 and outer surface 66 of the outer bearing support section 60 is approximately equal to the metal area between a cylindrical inner surface 156 and the cylindrical outer surface 64 of the inner bearing support section 58.

Similarly, the outer end portion 86 of the spindle 22 has a relatively small diameter and a relatively large metal thickness between its cylindrical inner and outer surfaces 162 and 164 (see Figs. 7 and 8). Since the grease seal section 96 has a larger diameter than does the inner bearing support section 58 (see Figs. 10 and 11), the radial thickness 168 of the grease seal section 96 is less than the radial thickness 154 of the inner bearing support section 58. However, the metal area between the cylindrical outer surface 170 and inner surface 172 of the grease seal section 96 is approximately equal to the metal surface areas on radial planes through the inner and outer bearing support sections 58 and 60. As was previously mentioned, the relatively thick wall section of the inner bearing support section 58 compared to the grease seal section 96 tends to strengthen the spindle 22 at the junction between these two sections where a relatively large stress is applied to the spindle 22 by the inner or main bearing assembly 40.

Although the axle spindle 22 has been illustrated in Fig. 2 as being formed separately from the axle 24 (Fig. 1) of the vehicle 20, it is contemplated that in certain types of vehicles the spindle and axle could advantageously be integral thus eliminating the necessity of connecting separate spindles to an axle during assembly of the evhicle. This construction is illustrated in Fig. 12 wherein a pair of identical spindles (one only shown) are integrally joined to respective ends of a common axle tube 194 by an annular weld 254. Although this specific combination axle and spindle constructed can advantageously be used with many different types of vehicles, it is contemplated that this construction will be particularly advantageous in association with house trailers and similar types of wheeled vehicles. Of course, the length of the axle 194 will depend upon the distance to be provided between the wheels of the associated vehicle.

The spindle 192 is illustrated in association with a brake support plate 198 of a house trailer. The spindle 192 includes an inner bearing section 200 on which an inner or main bearing assembly 202 is mounted. An outer bearing section 204 is co-axial with the inner bearing section 200 and supports an outer bearing assembly 206. A hub 208 of a wheel is rotatably supported on the spindle 192 by the bearing assemblies 202 and 206. Of course, another wheel (not shown) is supported in the same manner on the opposite spindle.

The inner bearing assembly 202 is positioned axially relative to the spindle 192 by a radially projecting shoulder section 212. A bearing nut 214 is mounted in threaded engagement with an outer end portion 216 of the spindle 192 and presses a washer 218 against the outer bearing assembly 206 to retain the wheel hub 208 on the spindle 192. A grease seal section 222 on the spindle 192 is engaged by a seal 224 mounted on the hub 208. The spindle 192 includes a base section 250 which is reduced at an axially outer end portion to form a mounting section 252 and connected to the grease seal section 222 by a radially inwardly and axially outwardly tapering shoulder section 228. The mounting section 252 is telescopically disposed within the axle tube 194 and joined thereto by the annular weld 254. The brake support place 198 is joined to the spindle 192 just inwardly of the shoulder section 228 by an annular weld 232.

The cold working process by which each of the spindles 192 is formed is substantially the same as the cold working process illustrated schematically in Figures 3 through 6 in association with the blank 110. Thus, a cylindrical blank having a uniform annular cross sectional configuration is positioned on an upstanding stake having an external

configuration substantially similar to the internal configuration of the spindle 192. One end portion of the blank is aligned with a central passage or opening in a die, similar to the die 114 of Figure 4, which is moved axially along the blank to plastically deform the wall of the blank radially inwardly at a temperature below the recrystallization temperature of the metal of the blank. The outer end portion of the blank will then be further cold worked to form the bearing support sections 200 and 204 and the outer end portion 216. It should be noted that the wall thickness of the spindle 192 increases as the diameter of the wall decreases in much the same manner as previously explained in connection with the blank 110.

Once the two spindles 192 have been integrally joined with the axle 194, the axle and spindles can be readily mounted on a vehicle in any suitable manner, such as by welding known mounting blocks or pads onto the axle.

If desired, an opening could be formed in the tubular wall of the axle 194 to enable suitable wires or leads to be run through the axle to the hollow spindles 192 to effect activation of an electric brake assembly for retarding rotation of a wheel of the trailer. Of course, these leads could be associated with equipment other than an electric brake assembly.

From the foregoing description it can be seen that a hollow axle spindle can be economically formed by plastically deforming a tubular metal blank at a temperature below the recrystallization temperature of the metal of the blank. During this cold working process bearing support sections are formed with sufficient dimensional accuracy and surface finish to enable the spindle to be used without machining the bearing support sections. Since the resulting axle spindle is hollow, its relatively light weight tends to minimize the upsprung weight of a vehicle with which it is associated. In addition, the axially extending cavities within the hollow spindles facilitate the installation of vehicle equipment requiring the extension through the spindle of a cable or other conductor. If desired, the hollow spindle can be integrally formed with the axle of a vehicle.

WHAT WE CLAIM IS:—

1. A method of forming a hollow axle spindle for use in supporting a vehicle wheel which, in use, is rotatably mounted on the spindle by a plurality of bearing assemblies located in axially spaced apart relationship between an outer end portion of the spindle and an inner end portion of the spindle connected with the vehicle, said method comprising the steps of: providing a metal blank of approximately the same length as the axle spindle and having an axially extending tubular wall having open ends and a substantially uniform external diameter with an annular cross-sectional configuration in a radially extending plane; providing a support stake having substantially the same external configuration as the internal configuration of the hollow axle spindle and having a first portion, a second portion and an intermediate portion between the first and second portions, the intermediate portion being of smaller cross-sectional area than said first portion, and the second portion being of smaller cross-sectional area than said intermediate portion. positioning the blank on the stake with one end portion of the blank adjacent to the first portion of the strike; providing a plurality of dies; cold forging at least a portion of the metal blank adjacent to the first and intermediate portions of the stake at a temperature below the recrystallization temperature of the metal of the blank by effecting relative axial movement between at least one of the dies and the blank and stake to form adjacent to the first portion of the stake a mounting end portion of the spindle for connection with a vehicle and form adjacent to the intermediate portion of the stake a first cylindrical bearing support section having substantially cylindrical inner and outer surfaces which extend substantially parallel to each other in a co-axial relationship with the longitudinal axis of the blank and are uniformly spaced from each other by a first distance; cold forging at least a portion of the metal blank with at least a second one of the plurality of dies at a location which is axially outwardly of the first bearing support section and at a temperature which is below the recrystallization temperature of the metal of the blank to form adjacent to the second portion of the stake a second cylindrical bearing support section having a smaller external diameter than the first cylindrical bearing support section and having substantially cylindrical inner and outer surfaces which extend substantially parallel to each other in a co-axial relationship with the first bearing support section and are uniformly spaced from each other by a second distance which is greater than the first distance between the inner and outer surfaces of the first cylindrical bearing support section thereby to form the second cylindrical bearing support section with a greater metal thickness in a radial direction than the first bearing support section, and removing the cold forged blank from the stake after performing the foregoing steps.

2. A method of forming a hollow axle spindle as claimed in claim 1, further in-

cluding the step of cold forging said one end portion of the blank at a temperature below the recrystallization temperature of the metal of the blank, said step of cold forging said one end portion of the blank including the step of expanding said one end portion of the blank radially outwardly to further form the mounting end portion of the spindle.

3. A method as set forth in claim 1 or 2, further including the step of cold forging said one end portion of the blank at a temperature below the recrystallization temperature of the blank, said step of cold forging said one end portion of the blank including the step of contracting said one end portion of the blank radially inwardly to form a positioning shoulder on the mounting end portion of said spindle.

4. A method of forming a hollow axle spindle as set forth in Claim 1, 2, or 3 further comprising the steps of plastically deforming a portion of the metal blank with at least a third one of the plurality of dies at a temperature which is below the recrystallization temperature of the metal of the blank to form a bearing positioning shoulder adjacent the end portion of the first bearing support section remote from the second bearing support section with a base section extending from the bearing positioning shoulder towards said one end of the blank and having inner and outer surfaces in a coaxial relationship with the first bearing support section and uniformly spaced from each other by a third distance which is less than the first and second distances of the first and second bearing support sections to thereby form the base section with a metal thickness which is less than the metal thickness of the first and second bearing support sections.

5. A method of making a hollow axle spindle substantially as herein described with reference to the accompanying drawings.

6. A hollow axle spindle for use in supporting a vehicle wheel which, in use, is rotatably mounted on the spindle by a plurality of bearing assemblies located in axially spaced apart relationship between an outer end portion of the spindle and an inner end portion of the spindle connected with the vehicle, when made by a method as claimed in any of the preceding claims.

7. A hollow axle spindle as claimed in claim 6 when appended to claims 4 and 3, the mounting end portion of which spindle is diposed in an opening in a support member connected to a vehicle, the positioning shoulder on the mounting end portion being disposed adjacent to a surface of said support member which extends transversely to the longitudinal axis of said spindle to position said spindle relative to said support member, and fastening means interconnecting said positioning shoulder on the mounting end portion and said support member.

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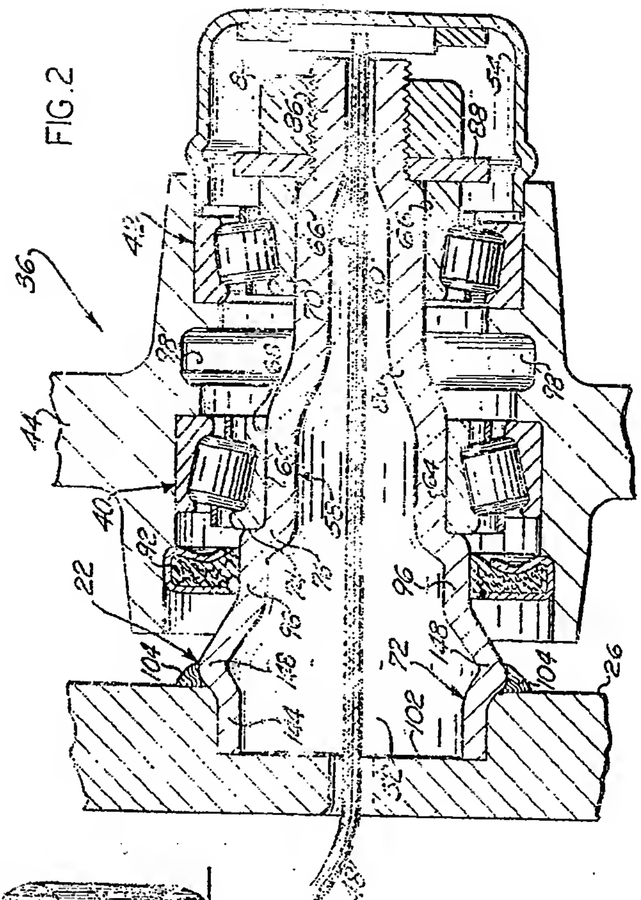
FIG. 2



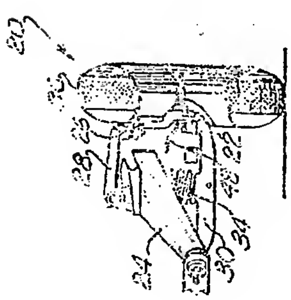


FIG. 1

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4 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 2

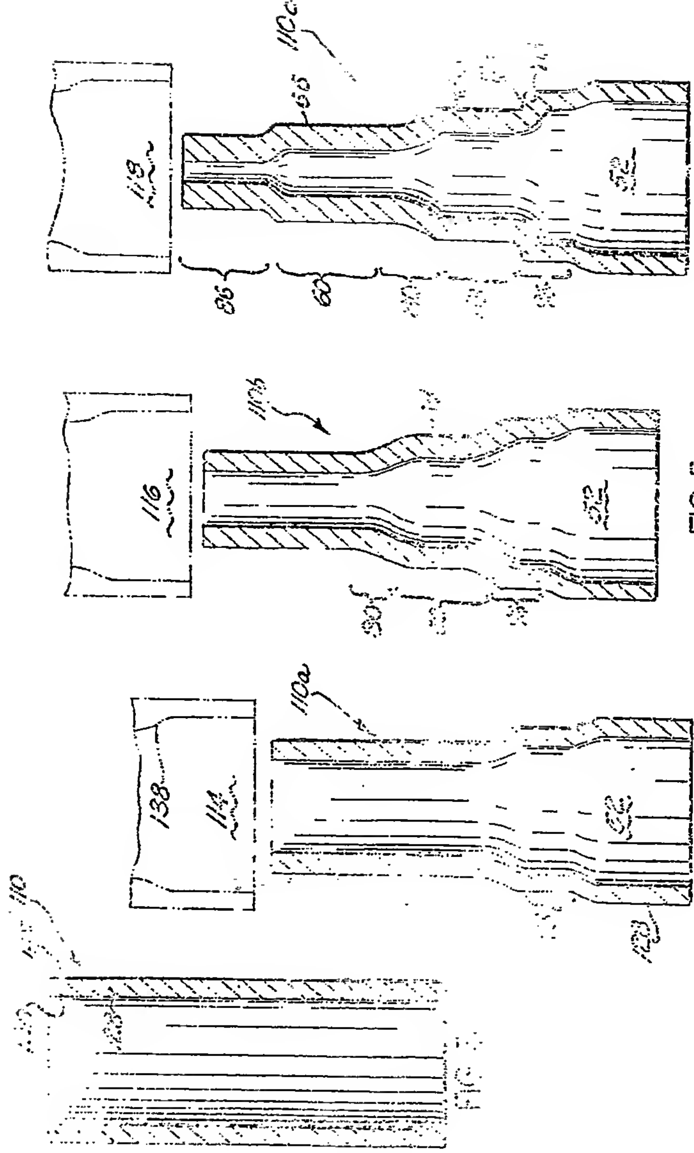

FIG.6

FIG.5

FIG.4

FIG.3

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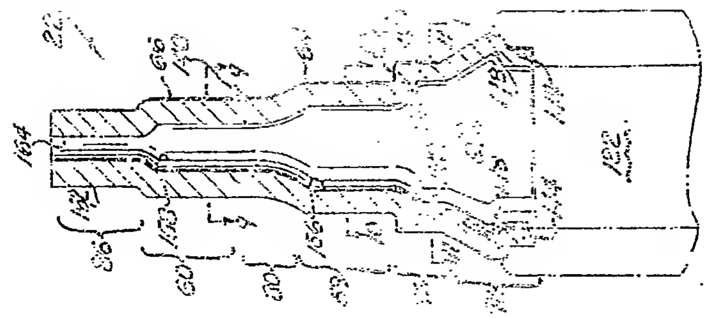


FIG. 8

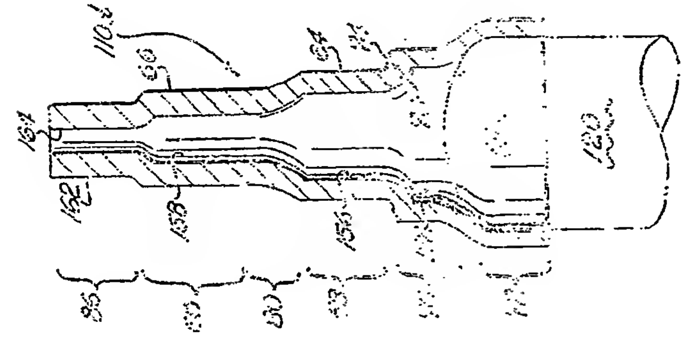


FIG. 7


FIG. 9


FIG. 10

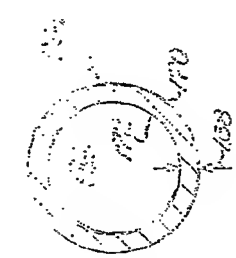
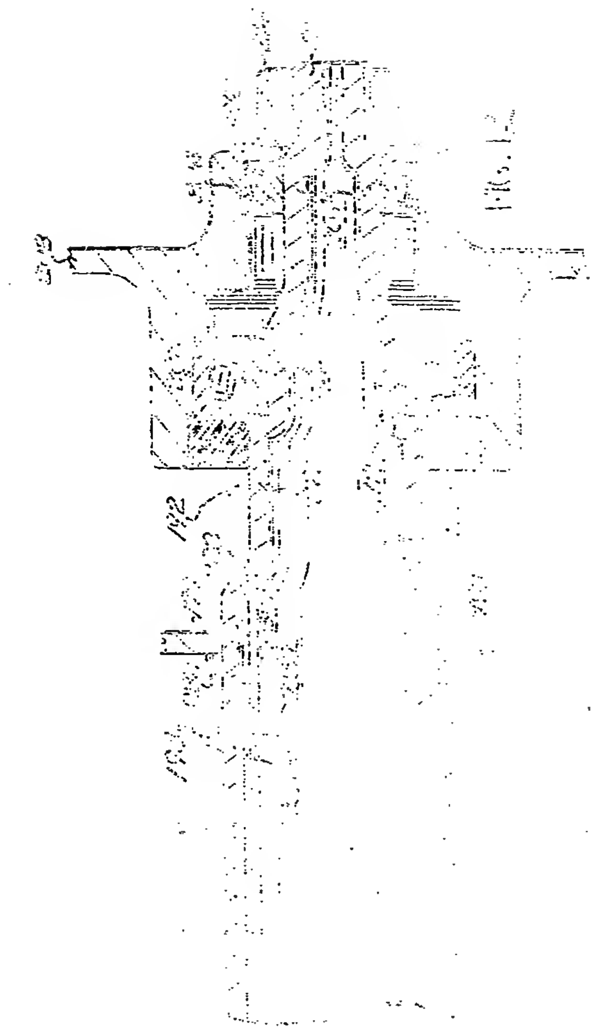


FIG. 11



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